

CHAPTER 3

ASSESSMENT OF SKILL RETENTION

3.1 Aim

In this section of the thesis, studies have been made about the ability of school pupils to retain and reproduce practical skills involved in scientific work which have been taught earlier.

The assessment of a pupil's ability to retain and reproduce knowledge and skill taught earlier could be taken as a measure of success in teaching.

Information gained thereby regarding each pupil's performance could be an important feedback material for rebuilding the future teaching strategy.

To carry out this investigation, a group of pupils has been taught how to carry out certain scientific manipulative skills and these were tested after some time to find out how much they could retain and reproduce.

Comparison of this result with the result of assessment of an untaught group (control group) would help us to exclude the effect of general knowledge/ability gained by pupil by simply growing up in a modern society and spending time in the intellectual environment of a school, and allow us to find out the pupil's ability to retain knowledge acquired during teaching sessions, and to reproduce it, assuming that the teaching was carried out at the highest possible standards.

3.2 Development of the study materials --- Preliminary runs

(i) Method

In this part of the work in which the retention ability of pupils was investigated, a trial run was carried out only for the testing session and not for the teaching session. A group of 5 pupils (14 years old) was invited to take part in this trial run. We were able to find out how many solid

samples each pupil could study in half an hour and how many runs of the second experiment (pH of the mixture of weak acid and weak alkali) were possible in half an hour.

In general the objective was to find out if the preparation of the worksheet and arrangement of the materials was adequate for the testing session.

(ii) Discussion of the findings of the trial run

No major (or significant) changes were required. The trial run was carried out as planned and the same procedure was repeated for the testing sessions.

3.3 Final run

(i) Method

In this section of the study, work was carried out in two stages; the first stage involves the teaching of practical skills and the second stage involves testing the pupils' ability to reproduce these skills after a gap of a certain period of time.

Four sets of fourth form pupils from a local comprehensive school (Earlham School, Norwich) took part in this study. There were approximately 25 pupils (boys and girls of age range 14-15 years) in each set.

For each of the four teaching sessions, organised at the end of their summer term, the pupils in each set were randomly divided into 3

groups. Group I was asked to carry out an experiment on the reaction of dilute hydrochloric acid (HCl) with sodium thiosulphate solution ($\text{Na}_2\text{S}_2\text{O}_3$) [see work-sheet 3.1 in Appendix 2.1]. Pupils in Group II were given a series of solid samples in ignition tubes and asked to heat them on a Bunsen burner and record their observations [see work-sheet 3.2 in Appendix 2.1]. All the materials needed for the experiments were supplied at the desk before the start of the work. Group III pupils watched a video film in which none of the skills used in the above mentioned experiments were involved.

For this experimental work, one large laboratory in Earlham School was used. The video film was shown in a small room adjacent to the laboratory. The laboratory floor was divided into 2 sections, one section contained the acid - thiosulphate solution experiment involving volume measurement by measuring cylinder, while the other section contained the heating of solids experiments.

All the necessary materials were prepared and arranged at the UEA earlier. On the day before the teaching session, these materials were moved to the school and laid out on the bench. In between the sessions, the chemical bottles were refilled and new sample tubes for heating experiments were placed on the desk. Lists of chemicals and apparatus used in experiment 3.1 and 3.2 are given in Appendix 2.2.

Pupils in Group I and II, engaged in the experimental work, were supervised by four science teachers (two for each group) who spent about one hour teaching various manipulative skills involved in the experiment.

The Group I pupils were taught how to measure accurately a certain volume of liquid using a measuring cylinder. They were asked to ensure that the lower meniscus of the liquid touched the required mark on the cylinder. For heating solids by Group II pupils, the following four manipulative skills, viz. (a) the position of the test tube holder, (b) angle of the test tube, (c) zone of the flame used in heating, and (d) colour of the flame, were thought to be important and the pupils were given thorough lessons on them, so that they could perform these skills correctly. The pupils were told that (i) the test tube holder should be kept close to the top end of the tube, (ii) the test tube should be held at an angle of about 45° and not pointing towards any person, (iii) the sample should be in the hot zone of the flame during heating, and (v) a blue coloured flame should be used for heating.

After two months of summer holidays, at the beginning of a new term, each of these pupils was asked to take part in experimental work for an hour and was given two experiments different from the previous ones, but involving the above-mentioned skills. The two experiments were: (i) the mixing of weak acid and weak alkali in different volume ratios and to determine the pH value of the mixture by using an indicator solution (see work sheet 3.3 in Appendix 2.1), and (ii) the heating of solids in ignition tubes and identification of the nature (acid/neutral/alkaline) of the gas given off (see work sheet 3.4 in Appendix 2.1). The first experiment provided the opportunity for assessing the volume measurement skill while the second experiment provided the opportunity for assessing the 4 manipulative skills involved in heating solids in a tube, as has been mentioned earlier in the teaching session.

It was the testing-time, i.e. the time to find out how much a pupil could remember and reproduce the skills which were taught earlier, and also to look at the performance of the pupils who did not receive lessons on any skill, in comparison with that of the pupils who were taught. For this purpose each set of about 25 pupils comprising samples from each of the 3 groups (i.e. measurement of volume group, heating group and video group/control group) was assessed in each session lasting for about an hour.

For this work, a spacious laboratory in Earlham School was used. It was the same laboratory as was used for the teaching sessions about two months previously.

The numbering of the work-stations, randomisation of the pupils, and their identification with number labels was carried out in the same way as has been described earlier for the previous experiment (experiment 2.1) in Chapter 2.

Materials required for both the experiments were laid out on the desk the previous day and some of the used chemicals were replaced in between the sessions. Appendix 2.2 contains the lists of chemicals and apparatus used in experiment 3.3. and 3.4. There were three sessions to assess three sets of pupils. Although four sets of pupils were given lessons, it was possible to assess only the three sets as the judges had to leave the laboratory to attend to other business before the commencement of the fourth session. However, for data analysis, it did not cause any difficulties as each set of pupils had almost an equal number of samples from the

three method groups (volume measurement, heating solid and control).

Each session, lasting for about an hour, was divided into two halves; one for the experiment involving measurement of volume and the other for the heating of solids in test tubes. Eight experienced science teachers acted as judges. In the first half of the session, each judge assessed the pupils' skill to measure volume of liquid using a measuring cylinder and in the second half, the assessment of the four skills involved in heating solids.

At the beginning of each assessment session, each of the 8 judges was provided with an assessment sheet (see appendix 2.1) to record the marks for the assessment of the five manipulative skills, one skill in the first experiment (experiment 3.3) and four skills in the second experiment (experiment 3.4) for each pupil. "1" mark was awarded for correct execution of each skill and a "0" mark for failing to do so. As a result each pupil obtained a maximum of 8 marks in experiment 3.3. (see work-sheet 3.3 in Appendix 2.1) and 32 marks in experiment 3.4 (see work-sheet 3.4 in Appendix 2.1) for correct execution of all the manipulative skills.

On the day before the assessment sessions took place, the judges were briefed clearly about the nature of their tasks and, following a discussion, they agreed upon a standard similar to that maintained during the teaching sessions, regarding the correctness of the manipulative skills. As the judges were different from the teachers involved in the earlier teaching sessions, they had no knowledge of the grouping of the pupils and this helped them to assess the pupils in an unbiased manner (without knowing who had lessons on what skill).

3.3. (ii) Results and Discussion

The achievement of pupils belonging to all the three groups in each of the three sessions in carrying out the practical skills involved in two experiments have been determined by collating the results of the assessment from 8 judges' mark-sheets.

Appendix 2.3 contains the "raw-data", i.e. the judges' mark sheets for all three sessions of the assessment. "✓" and "✗" in the mark-sheets indicate the correct and incorrect execution of the manipulative skills. Assigning mark "1" for "✓" and mark "0" for "✗", the total marks (achievement) obtained by each pupil from 8 judges were calculated and are given in Table 3.1 (for session -1), Table 3.2 (for session -2) and Table 3.3 (for session -3). As each session comprised an almost equal number of pupils belonging to the 3 method groups (volume group, heating group and control group) and following the randomised division during the teaching period earlier, the results of all 3 sessions were used in the analysis to calculate an average achievement value of the pupils belonging to each method group and for carrying out 5 skills (one in experiment 3.3 and four in experiment 3.4).

The mean values of achievement obtained from the analysis of the experimental data are presented in Table 3.4.

In experiment 3.3, which involves the measurement of volume, pupils in group I who had lessons in this skill have scored significantly better than the other two groups, whose achievements are very similar to each other. In experiment 3.4, pupils who had lessons on heating solids, have

produced, on the whole, (i.e. considering all the skills involved) better results than the other two groups. As separate skills are involved in experiment 3.4, the results were further analysed to understand more clearly the pupils' performance in each of the skills. For the two tasks concerned with the position of the test-tube holder and angle of the tube, there is no significant difference^{ee} (considering the s.d) between the achievement of each group in carrying out these two skills. For the task concerned with the zone of the flame, each group, even the taught one, produced poor results suggesting that teaching of the skill had no permanent effect on the pupil.

However, in the task concerned with using the correct colour of flame, all three groups have very high mean scores. Thus it would have been extremely difficult to improve on their answers by this teaching.

The results indicate that the pupils who were given lessons on a practical skill can perform this skill better than those who have not, even after two months holiday, during which they did not take part in any academic activity involving the practical skill. In experiment 3.3 the taught group is twice as good as the untaught group, while in experiment 3.4 the taught group is slightly better than the untaught groups.

In order to understand more clearly the effect of the variables on the variability in score discussed above, further analysis of the pupils' achievement data was carried out.

Several 3X3 ANOVA based on randomised groups were done.

They were as follows:

- i) In experiment (3.3):- 3 method group (A) X 3 sets (B)
- ii) In experiment (3.4),
skill (a):- 3 method group (A) X 3 sets (B)
- iii) In experiment (3.4),
skill (b):- 3 method group (A) X 3 sets (B)
- (iv) In experiment (3.4)
skill (c):- 3 method group (A) X 3 sets (B)
- (v) In experiment (3.4)
skill (d):- 3 method group (A) X 3 sets (B)

Information derived from the ANOVA is in Tables 3.5.

It seems from the analysis of variable (F_A is significant at $p < 0.0001$ level)

that in experiment 3.3, the teaching of volume measurement has a significant effect on the final results discussed earlier. The significance of F_A values also indicates that in experiment 3.4, the teaching of two skills, viz. (a) position of the test tube holder, and (b) angle of the tube-tube, has a significant effect on the final results; whereas teaching of other two skills,

viz. (c) zone of the flame, and (d) colour of the flame, has no significant effect on the final results. The statistical analysis of pupils' achievement data support the conclusion drawn earlier regarding the variability in score due to different conditions in the variable (i.e. method group: taught group vs. untaught group). On the basis of F_B or $F_{A \times B}$ value, it can be suggested that the overall results gathered were not affected significantly due to the fact that the subjects (pupils) belonged to three sets and they were assessed in three separate sessions.

Table 3.1

Total marks obtained by each pupil assessed by 8 judges in Session 1 for carrying out volume measurement in experiment 3.3 and heating solids in experiment 3.4.

Pupil No.	Experiment 3.3 max marks = 8	Experiment 3.4			
		Position of test tube holder max marks = 8	Angle of test tube max marks = 8	Zone of flame max marks = 8	Colour of flame max marks = 8
1 H	3	6	8	3	7
2	-	-	-	-	-
3	-	-	-	-	-
4 V	7	7	6	1	5
5 V	8	7	8	5	8
6	-	-	-	-	-
7 C	2	8	6	3	8
8 C	2	5	7	1	8
9 C	4	0	8	8	8
10 V	8	2	4	6	8
11 H	2	7	8	0	8
12 V	5	3	5	1	8
13 H	4	7	8	8	8
14 V	6	5	7	5	8
15 H	1	7	5	5	8
16 H	7	7	8	3	8
17 C	7	8	7	6	6
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21 V	8	3	3	7	7
22 V	3	7	4	7	6
23 C	7	4	8	5	8
24 H	0	8	7	7	8
25 C	5	7	7	6	7

V/H/C in Column one indicate the group (volume measurement/heating solids/control) they belonged to during the teaching sessions earlier.

Table 3.2

Total marks obtained by each pupil assessed by 8 judges in Session 2 for carrying out volume measurement in experiment 3.3 and heating solids in experiment 3.4.

Pupil No.	Experiment 3.3 max marks = 8	Experiment 3.4			
		Position of test tube holder max marks = 8	Angle of test tube max marks = 8	Zone of flame max marks = 8	Colour of flame max marks = 8
1 H	5	7	7	4	0
2	-	-	-	-	-
3 C	2	2	4	3	7
4 C	6	3	7	1	8
5 H	7	7	7	0	8
6 H	5	8	8	3	8
7 H	1	7	7	0	7
8 C	4	5	6	2	8
9	-	-	-	-	-
10 V	7	4	7	5	8
11 V	8	7	1	1	8
12 C	2	2	3	2	8
13 H	3	5	7	6	8
14	-	-	-	-	-
15 C	1	6	8	7	8
16 H	4	7	8	6	8
17 V	7	7	8	6	8
18 V	8	7	8	3	8
19 V	7	7	3	1	0
20 H	1	3	6	0	0
21 C	5	3	2	1	0
22 C	4	2	5	5	3
23 V	8	8	3	5	5
24 V	7	8	6	6	5
25	-	-	-	-	-

V/H/C in Column one indicate the group (volume measurement/heating solids/control) they belonged to during the teaching sessions earlier.

Table 3.3

Total marks obtained by each pupil assessed by 8 judges in Session 3 for carrying out volume measurement in experiment 3.3 and heating solids in experiment 3.4.

Pupil No.	Experiment 3.3 max marks = 8	Experiment 3.4			
		Position of test tube holder max marks = 8	Angle of test tube max marks = 8	Zone of flame max marks = 8	Colour of flame max marks = 8
1 H	0	6	5	1	7
2 V	7	2	2	0	7
3 V	1	3	4	1	8
4 V	6	4	2	1	6
5 C	2	2	0	5	2
6 C	3	6	7	2	8
7 C	3	3	3	5	8
8 C	4	7	6	3	8
9	-	-	-	-	-
10 V	5	1	4	1	8
11 C	3	7	8	2	4
12 C	3	7	5	0	8
13 V	5	3	4	2	8
14 C	2	8	1	2	8
15 V	3	4	1	2	8
16 V	4	3	2	0	8
17 H	1	7	7	2	8
18	-	-	-	-	-
19 H	5	7	6	5	4
20 H	5	7	8	7	7
21	-	-	-	-	-
22 C	1	7	6	5	8
23 H	5	8	7	8	8
24	-	-	-	-	-
25 H	5	7	7	8	8

V/H/C in Column one indicate the group (volume measurement/heating solids/control) they belonged to during the teaching sessions earlier.

Table 3.4

Mean values of the achievement of different groups of pupils in carrying out several practical skills in two experiments

Expt.	Practical skill assessed	Measurement of volume group		Heating of solids group		Control group	
		x	s.d.	x	s.d.	x	s.d.
3.3	Measurement of volume	6.10	± 1.98	3.37	± 2.18	3.28	± 1.80
3.4	(a) Position of the test tube holder	4.86	± 2.21	6.74	± 1.12	4.86	± 2.42
	(b) Angle of the test tube	4.24	± 2.22	7.05	± 0.94	5.43	± 2.34
	(c) Zone of flame	3.14	± 2.42	4.00	± 2.87	3.52	± 2.17
	(d) Colour of flame	6.90	± 1.90	6.74	± 2.49	6.71	± 2.31

(x = mean value, s.d. = standard deviation)

Table 3.5

Summary tables for 3X3 completely randomised ANOVA of the results of studies on pupils' ability to retain scientific manipulative skills in experiment 3.3 and 3.4. (All the assessments were carried out by Method -T).

(a) Experiment 3.3 Measurement of volume using measuring cylinder

Source of variance	SS	df	MS	F (obsv.)	F (crit)	Significance of F (obsv.)
A (3 method group)	98.26	2	49.13	13.80	8.25 at (p=0.001)	Significant at $p < 0.001$
B (3 class/set)	23.60	2	11.80	3.31	3.23 at (p=0.05)	Significant at $p < 0.05$
A X B	24.85	4	6.21	1.74	2.61 at (p=0.05)	n.s. ($p < 0.05$)
Error	160.50	45	3.56	-	-	-
Total	307.21	53	-	-	-	-

(b) Experiment 3.4 Heating of solids (skill tested: Position of the test tube holder)

Source of variance	SS	df	MS	F (obsv.)	F (crit)	Significance of F (obsv.)
A (3 method group)	60.77	2	30.39	10.16	8.25 at (p=0.001)	Significant at $p < 0.001$
B (3 sets)	4.11	2	2.06	0.69	3.23 at (p=0.05)	n.s. ($p < 0.05$)
A X B	53.78	4	13.45	4.50	3.83 at (p=0.01)	Significant at $p < 0.01$
Error	134.67	45	2.99	-	-	-
Total	253.33	53	-	-	-	-

(c) Experiment 3.4 Heating of solids (skill tested: Angle of the test tube)

Source of variance	SS	df	MS	F (obsv.)	F (crit)	Significance of F (obsv.)
A (3 method group)	72.26	2	36.13	10.79	8.25 at (p=0.001)	Significant at ($p < 0.001$)
B (3 sets)	26.93	2	13.46	4.02	3.23 at (p=0.05)	Significant at ($p < 0.05$)
A X B	13.96	4	3.49	1.04	2.61 at (p=0.05)	n.s. at ($p < 0.05$)
Error	150.54	45	3.35	-	-	-
Total	277.65	53	-	-	-	-

Table 3.5

(d) Experiment 3.4 Heating of solids (skill tested: Zone of flame)

Source of variance	SS	df	MS	F (obsv.)	F (crit) at p=0.05	Significance of F (obsv.)
A (3 method group)	14.93	2	7.46	1.29	3.23	n.s. ($p < 0.05$)
B (3 sets)	22.26	2	11.13	1.92	3.23	n.s. ($p < 0.05$)
A $\times$ B	37.07	4	9.27	1.60	2.61	n.s. ($p < 0.05$)
Error	261.17	45	5.80	-	-	-
Total	335.43	53	-	-	-	-

(e) Experiment 3.4 Heating of solids (skill tested: Colour of flame)

Source of variance	SS	df	MS	F (obsv.)	F (crit) at p=0.05	Significance of F (obsv.)
A (3 method group)	1.02	2	0.51	0.11	3.23	n.s. ($p < 0.05$)
B (3 sets)	12.26	2	6.13	1.26	3.23	n.s. ($p < 0.05$)
A $\times$ B	4.32	4	1.08	0.22	2.61	n.s. ($p < 0.05$)
Error	218.33	45	4.85	-	-	-
Total	235.93	53	-	-	-	-

In tables 3.5 (a) - (e):

F (obsv.) denotes the value of F ratio obtained from the experimental results.

F (crit) denotes the critical value of F ratio at a given level of significance (i.e. p value) and at the appropriate df values (see reference 50 for the relevant statistical tables).

n.s. means "not significant". This refers to the fact that the value of observed F ratio is less than the critical value of F at p=0.05 and thus F (observed) is not significant at $p < 0.05$ level. However, when F (observed) is higher than the F (critical) value at p=0.05, 0.01 or 0.001, the F (observed) is thought to be significant at the corresponding level of significance (p-value).